Manufacturing, Metal cutting, In-situ observation

Direct observations of tribological behavior in cutting with textured cutting tools

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Abstract

As widely reported in the literature, the micro-texturing technique has a significant potential to improve the performance of cutting tools by reducing cutting forces, friction, temperature, and tool wear, and further, by improving tribological behavior at the tool-chip and tool-workpiece interface. However, it is also known that the effects of textures on the cutting tool surface strongly depend on the texture geometry and dimensions, and that the application of indiscriminate surface textures to cutting tools often results in adverse effects on cutting performance, indicating that an improved understanding of surface phenomena is required to further develop textured cutting tools. To overcome this situation, this study describes how the textured surface on a cutting tool affects the deformation fields during the cutting process, including both the primary and secondary shear zones, by means of direct in-situ observation using PIV analysis.

Background & Results

Surface texturing technology has recently attracted a great deal of attention as a means of improving tribological behavior at the tool-chip/workpiece interface in the cutting process (Fig. 1). However, despite the body of prior work that clearly shows the significance of texture designs, there are no specific guidelines for designing effective textures for cutting tool surfaces, indicating that an improved understanding of surface phenomena is required to further develop textured cutting tools. This study describes how the textured surface of a cutting tool influences the deformation fields of the workpiece material, including both primary and secondary shear zones, by means of direct in-situ observation using particle image velocimetry analysis to understand the behavior in the vicinity of the textured surfaces during the cutting process (Fig. 2). The experimental results with the textured cutting tool reveal that the effect of the grooved rake face on the cutting force differs depending on the relative position of the microgroove with respect to the undeformed chip thickness. The friction condition and where the texture is located determine the performance of the surface texture (Fig. 3).

Significance of the research and Future perspective

In recent years, various challenges, such as dry machining, high-speed machining, and machining of difficult-to-cut materials, have been emerges in the field of metal cutting. On the other hand, our study clearly shows that the technology of applying surface textures to cutting tool surfaces has significant potential to achieve high-performance machining in various applications in the field of manufacturing.

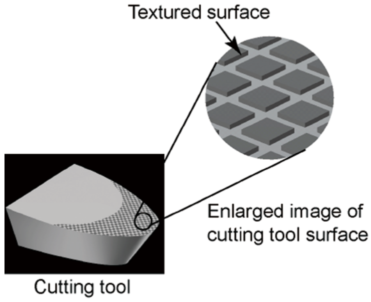

Fig. 1 Concept of the textured cutting tool

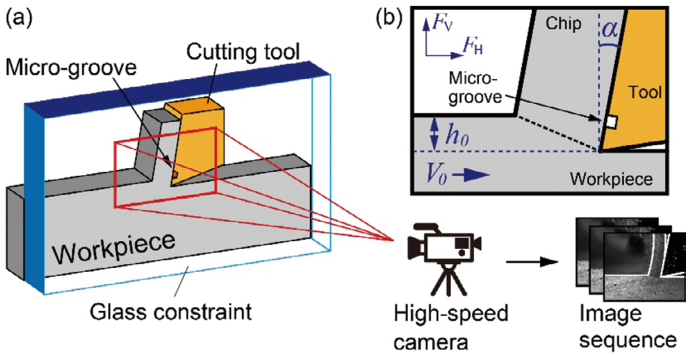

Fig. 2 In-situ observation of the metal cutting process

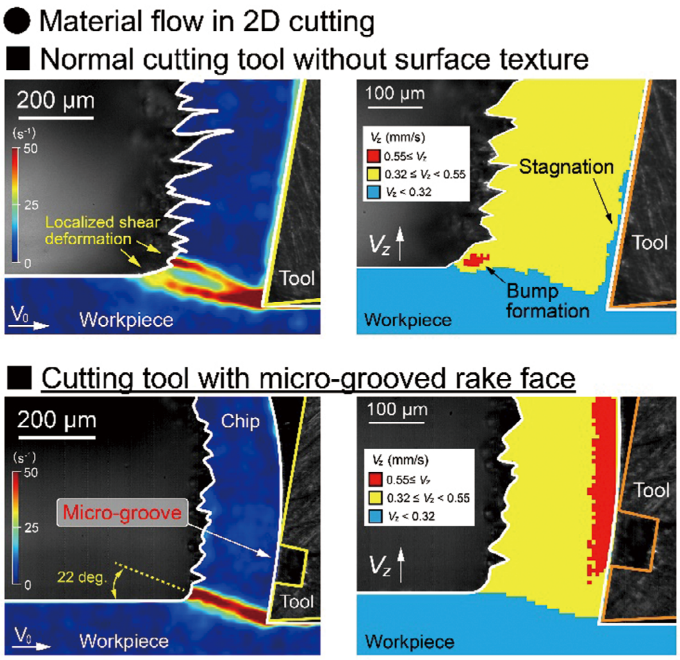

Fig. 3 Material flow in the vicinity of the cutting point

Patent

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